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Applicant(s):	Allan Madsen
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Title:	DEVICE AND METHOD FOR FORMING A SET OF CELLS FOR TIME DIFFERENCE MEASUREMENTS, AND FOR MEASURING TIME DIFFERENCE FOR LOCATING A USER OF A MOBILE TERMINAL
Art Unit:	2681
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Docket No.:	112740-936

Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

SUBMISSION OF CERTIFIED COPY OF PRIORITY DOCUMENT

Sir:

Please enter of record in the file of the above application, the attached certified copy of European Application No. 03002992.0 February 11, 2003. Applicant claims priority of February 11, 2003, the earliest filing date of the attached European application under the provisions of Rule 55 and 35 U.S.C. §119, and referred to in the Declaration of this application.

Although Applicant believes no fees are due with this submission, the Commissioner is authorized to charge any fees which may be required, or to credit any overpayment to account No. 02-1818.

Respectfully submitted,

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Dated: August 11, 2004

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Bescheinigung | Certificate | Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

03002992.0

CERTIFIED COPY OF PRIORITY DOCUMENT

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Anmeldung Nr:
Application no.: 03002992.0
Demande no:

Anmeldetag:
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Anmelder/Applicant(s)/Demandeur(s):

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

A device and method for forming a set of cells for time difference measurements, measuring time differences and locating a user of a mobile terminal

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
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AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL
PT SE SI SK TR LI

Description

Title of the invention

A device and method for forming a set of cells for time difference measurements, measuring time differences and locating a user of a mobile terminal

Field of the invention

The invention relates to forming a set of cells for time difference measurements, and, more specifically, to measure said time differences for locating a user of a mobile terminal.

Background art

If someone is in trouble or notices something alarming happening around, and dials the emergency number, such as 112 in Europe or 911 in the US, the emergency services (police, ambulance, fire brigade) need know where the help is needed. The caller may, especially under difficult circumstances, such as at night, or in a location not known to the caller, find it extremely difficult to give route guidance for the emergency services.

Mobile terminals are widely used; their penetration has in many countries reached and exceeded 90% of the total population. As a consequence, most people are carrying a mobile terminal along themselves while being away from home.

Cellular networks can be arranged to measure the coordinates of a mobile terminal of a subscriber under network coverage. One of the straightforward solutions is then to use this location information of the mobile terminal for locationing the subscriber who is calling an emergency number.

In the US, each cellular carrier is required to implement the E911 service as required by the Federal Communications Commission (FCC) in its order FCC 02-283 which at the time of writing (February 3, 2003) can be found in the Internet from address http://hraunfoss.fcc.gov/edocs public/attachmatch/FCC-02-283A1.pdf. Originally, the locationing accuracy in the so-called Phase II was first specified to 100 meters for 67% of calls and 300 meters for 95% of calls. From early October 2003 (see http://www.fcc.gov/Bureaus/Wireless/News Releases/2001/nwl0127a.pdf) the locationing accuracy will be enhanced to 50 meters for 67% of calls and 150 meters for 95% of calls.

For Global System for Mobile communications GSM, the locationing is usually performed by using the so-called Enhanced Observed Time Difference E-OTD method.

It is possible to make the locationing measurements in idle mode; this kind of approach is used by some manufacturers. Typically, the locationing interval is around 10 seconds. Then the locationing history is already known by the mobile terminal MS when it enters dedicated mode. Not only the location but also speed and direction if any can be determined.

Some other manufacturers do not use idle mode measurements but the location of the mobile terminal is found out only in the beginning of each 911 or 112 call. At the moment they seem to have at least some problems in obtaining the desired accuracy. According to some opinions, in order to achieve the accuracy requirements it is necessary to execute idle mode measurements for neighbour cells.

The problem of state-of-the-art solutions is then that the continuously performed measurement of time differences consumes very much power significantly reducing the standby time of the mobile terminal; the battery has to be recharged very often. This is an undue burden for most mobile subscribers, because the mobility of the user is then very limited while the battery of the mobile terminal is being recharged.

One solution for channel measurements disclosed in international patent application WO 2001/58201 is that the mobile terminal receives a neighbour cell list from a base station. Channel quality measurements are performed for the cells on the list, based on the location of the mobile device. This is performed in order to reduce the power consumption in the terminal.

The solution proposed in '201 is, however, far from optimal for locationing measurements. It cannot be used if the location of the mobile station is not known. Further, it has turned out to be extremely difficult to construct neighbour cell lists in such a manner that they would not only provide enough cell reselection possibilities but also enable good enough quality for time difference measurements still saving power in the mobile terminal.

Summary of the invention

It is the main objective of the invention to bring about a method and a device with which it is possible to form a set of cells for time difference measurements and to perform the measuring of time differences and the locationing of a user

of a mobile terminal more economically thus using less power in the mobile terminal.

This and other objectives of the present invention can be achieved by using a method and a device in accordance with any one of the patent claims.

A prior art method for forming a set of cells for time difference measurements for a mobile terminal camped on a first cell of a cellular network and being in idle mode comprises the steps of i) receiving a first set of cell identifiers of neighbour cells for said first cell; each of said cells sending a radio signal and ii) measuring received signal strength for cells the identifiers of which are included in the first set; a number N of cells having a signal strength exceeding a predefined thresshold constituting a set of available cells.

This method can be improved by further performing the steps of: i) reading a synchronization channel for the set of available cells, thereby measuring time differences for available cells, and then ii) selecting a second set from the set of available cells using a predefined selection rule, the second set including M < N cells, thus forming a set of cells for time difference measurements. The advantage obtained by the improvement is that the resulting second set is more compact than the set of available cells.

The enhanced method for forming a set of cells for time difference measurements for a mobile terminal camped on a cell of a cellular network and being in idle mode can be used for enhancing the efficiency of measuring of time differences for the mobile terminal camped on the cell measuring time

differences for cells in the second set only. In this manner the mobile terminal saves energy and the standby time is prolonged.

Especially, a cell from the set of available cells is selected to the second set whenever:
1) a base station identity code of the cell is not equal to a base station identity code of any other cell available, or 2) if a base station identity code of the cell is equal to a base station identity code of any other cell available, and:
2.1) its measured time difference deviates from measured time differences for other cells sharing the same base station identity code more than a predefined threshhold; or 2.2) it has the largest signal strength among all cells sharing the same base station identity code and having a measured time difference deviating less than or equal to the predefined threshhold. The advantage of such a mapping rule is that especially cells having same base station identity code need not be measured if it is very probable that the cells belong to one sectorized base station. By using all such cells for obtaining more time differences, especially for locationing purposes, would only consume more energy without bringing much detailed positioning information.

According to one aspect of the invention, the location of the user can be obtained using time differences obtained in accordance with other aspects of the present invention. One advantage from this is that the positioning system can be compatible with the mobile terminal, and can handle a smaller number of time differences than expected, for example.

Short description of the drawings

In the following, the invention and its preferred embodiments are described more closely referring to the examples shown in Figures 4 to 5 in the appended drawings, wherein:

Figure 1 shows a typical cellular network, such as a GSM network;

Figure 2 shows some cells of a cellular network 100;

Figure 3 shows how E-OTD measurements are performed in prior solutions;

Figure 4 is a flow chart showing an algorithm using which a set of cells is selected and then further used for measuring time differences; and

Figure 5 is an example showing some aspects of cell selection performed according to one aspect of the present invention.

Like reference signs refer to corresponding parts and elements throughout Figures 1-5.

Detailed description of the invention

Figure 1 shows a typical cellular network 100, such as a GSM network. Characteristic for the cellular network 100 is that it has a plurality of base stations 104. Each of these base stations 104 forms a cell 103a, 103b, 103c. Figure 1 shows only a small proportion of cells 103 for the sake of clarity. A mobile station 101 camps on one of these cells 103a, 103b, 103c. In other words, when the mobile station 101 is camping

on cell 103a, it is under radio coverage of base station 104a.

Typically, base stations 104 are adapted to form cells in such a manner that some cells 103 overlap with each other. Such a construction enables a flexible changing from one cell 104 to another. When the mobile station 101 is in dedicated mode, such as when there is an ongoing phone call, the changing from one cell 104 to another is called handover. When the mobile station 101 is in idle mode, the changing from one cell 104 to another is called cell reselection. Typically, cell reselection or handovers are performed when the mobile terminal 101 has moved so that the quality of the radio connection between the base station 104 and the mobile station 101 starts to degrade. When the cell reselection includes changing a location area, this is reported to the BSC.

In order to decide whether a handover or cell reselection is necessary, and further, to which cell the handover or cell reselection should be made, the mobile station 101 continuously measures received signal strength of its neighbour cells.

Usually, in order to avoid interference, each cell has a frequency different than its neighbour cell. There are also more than one cellular network 100 overlapping, meaning that a subscriber roaming under network 100 may not be able to use that different network geographically covering the same area. This is one of the reasons why each cell 103 has a so called neighbour list, sometimes referred to as the BA list. The neighbour list is a cell-based list which includes identifiers of such closest neighbours for the cell 103 which

belong to the same cellular network 100. The mobile terminal 101 therefore measures the signal strengths of only these cells 103 the identifier of which were included in the neighbour list.

The cellular network 100 knows the location of mobile terminal 101 in accuracy of a location area LA. Typically, an LA includes several cells 103a, 103b, 103c. Visitor Location Register 110 knows under which LA the mobile terminal 101 is and when a call is terminating to the mobile terminal 101, it is paged via a Base Station Controller BSC 106. BSC is the element which controls a plurality of the base stations 104. Usually, a cellular network 100 includes also a plurality of BSC. The Mobile Switching Center MSC 108 coordinates the different BSCs 106 and then takes care of switching of the traffic to and from different mobile terminals 101. The MSC 108 is usually connected via a Gateway MSC 112 to other cellular networks 100B having a similar structure.

This kind of hierarchy and operational model enables the roaming of mobile station 101, originally coming from another cellular network 100B, under cellular network 100. The cellular network 100B has its own subscribers, the data about whom is stored in Home Location Register HLR 114. The HLR 114 includes all services etc. which there are for a given subscriber of the cellular network 100B. In general, in order to reach a subscriber, the HLR 114 knows the VLR 110 address under which the subscriber is.

For locationing purposes there are Location Services Center LCS 109 connected into cellular network 100. The LCS 109 is used, for example, when a subscriber is missing. As explained above, the cellular network 100 knows within the accuracy of

a location area LA where the user is, whereas the other cellular network 100B knows only in the accuracy of a VLR 110 area where the user is. Basically, the locationing of the user or mobile terminal 101 can be performed from LCS 109B from cellular network 100B as well, if the operators of cellular networks 100 and 100B have agreed on that.

Because of some legislative considerations, usually there are no problems for an authorized user making a query to LCS 109B if the subscriber is roaming under his home cellular network 100B. If the authorities are looking for the user in the geographical area of his/her own cellular network 100B but he/she is roaming under cellular network 100, the authorities need to collaborate with authorities authorized in making LCS inquiries for LCS 109.

Figure 2 shows some cells of a cellular network 100. The mobile terminal 101 is camping on cell A having dimensions denoted by curve C_A. The cell A has neighbour cells B, C, and D. Cell C is a sectorized cell, so that it includes three sectorized transmitter/receiver units TRX. The sectors C1, C2, and C3 have dimendions denoted by curves C_{C1}, C_{C2}, C_{C3}, respectively. Cells B and D have dimensions denoted by curves C_B and C_D. The position of the mobile station 101 is denoted by point P.

Figure 3 shows the principle how state-of-the-art locationing measurements are performed. Typically, such measurements are used to produce Enhanced Observed Time Difference E-OTD information, which can then be used to interprete the quite accurate location of the user.

When the mobile terminal camps on cell A, it receives the neighbour list from cell A. The neighbour list includes Absolute Radio Frequency Channel Number ARFCN of the Broadcast Control Channel BCCH. The ARFCN is used to select the right frequency from the multitude of different frequencies. The synchronization channel of all these cells in the neighbour list is read before their base station identity codes BSIC can be obtained. BCCH is used to send controlling information to downlink direction; such controlling information includes synchronization frames which are sent in the part of BCCH known as Synchronization Channel SCH.

The mobile terminal measures received signal strength for the cells included in the neighbour list. Then it decides to read SCH for those cells the signal stregth of which exceeds a predefined threshold, i.e. which are available. The moment on which the receiving of a data frame in the synchronization table begins is marked as Time of Arrival TOA for the cell.

In our simple example, cell A has a Base Station Identifier Code BSIC "A". BSIC is "B" for cell B, "C" for sectors C1 and C2, and "D" for cell D. Sector C3 is below the predefined thresshold i.e. mobile terminal 101 cannot hear it well enough.

Cell A has BCCH "a". For B the BCCH is "b", for sector C1 and C2 "c1" and "c2", respectively, and for D the BCCH is "d".

TOA of A is T_A, of B T_B, of C1 T_{C1}, of C2 T_{C2}, and of D T_D.

Then, the OTD is $T_B - T_A$ for cell B, T_{C1}

- T_A for sector C1, and T_{C2} - T_A for sector C2. For cell D, the OTD is T_D - T_A. So the principle is that the time difference is computed as the difference from the serving cell A.

The mobile station 101 keeps on measuring all these OTDs periodically. The measurement period depends on the implementation, but a 10 second interval between measurements seems to be satisfactory for locationing purposes.

Figure 4 shows one aspect of the present invention. In step L11 mobile terminal 101 camps on cell A. In step L13 it receives a neighbour list of cell A, the neighbour list being referred as first set.

In step L15 the mobile terminal 101 measures the received signal level for each cell the indentifier of which was in the neighbour list i.e. in the first set. Then in step L17 the mobile station 101 defines the set of available cells. As described above, a cell is determined to be available if the received signal strength is above a predefined threshhold value. In some implementations, only a limited number (such as 6) of the strongest neighbour cells are selected, whereas for some other implementations all cells for which the received signal strength exceed some value characteristic for the mobile station are selected.

In step L19 the synchronization channel SCH is read for cells available. In step L21 the mobile station 101 timer value at the beginning of each synchronization frame is stored, this corresponding measuring time differences for available cells. In all occasions, is not necessary to read the SCH for measuring the time differences. Depending on the cellular

network structure, the timing can also be measured in some other way.

According to one aspect of the present invention, the second set is in step L23 selected from the set of available cells using a predefined selection rule. Then in step L25 synchronization channel SCH could be read for the cells which belong to the second set.

In step L27 the time differences are measured for cells the identifiers of which are included in the second set only. The timer value at the beginning of each synchronization frame is stored, this corresponding measuring time differences for the cells in the second set.

According to one aspect of the present invention, predefined mapping rule reads at least partially: a cell from the set of available cells is selected to the second set whenever:

- i) a base station identity code of the cell is not equal to a base station identity code of any other cell available;
- ii) if a base station identity code of the cell is equal to a base station identity code of any other cell available, and:
  - 1) its measured time difference deviates from measured time differences for other cells sharing the same base station identity code more than a predefined threshhold; or
  - 2) it has the largest signal strength among all cells sharing the same base station identity code and having a measured time difference deviating less than or equal to the predefined threshhold.

In step L29 it is checked whether or not the synchronization channel has to be read for all cells in the neighbour cell list, i.e. the cells in the first set. This has to be performed occasionally. Specification 3GPP TS 05.08 V7.7.0 defines (clause 6.6.1) that "The mobile station shall attempt to check the BSIC for each of the 6 strongest non-serving cell BCCH carriers at least every 30 seconds, to confirm that it is monitoring the same cell. If a change of BSIC is detected, then the carrier shall be treated as a new carrier and the BCCH data re-determined."

The exit criteria for LOOP2 to be tested in step L29 can include any or a plurality of the following: i) LOOP2 has been executed a predetermined number of times (1, 2, 3, 4, 5, ...) after performing step L15 (counter expiry); ii) the mobile terminal 101 is changing from idle mode to dedicated mode; iii) the step L25 i.e. reading the synchronization channel SCH for cells in the second set has failed; iv) timer expiry; cell reselection; or v) neighbour list changed.

Option iii) corresponds to the case that the subscriber is moving and the synchronization channel of at least some of the cells in the second set cannot be received without errors.

If none of the exit criteria for LOOP2 is met, the execution of LOOP2 is continued, i.e. steps L25, L27, and L29 are repeated. If any of the exit criteria for LOOP2 is met, the LOOP1 is executed, i.e. the mobile terminal measures received signal level in step L15 and so on. However, if a new neighbour cell list is being received, then the LOOP1 extends to step L13.

Figure 5 shows some further considerations relating to the present invention. The contents of Figure 5 include more or less everything from Figure 3. In addition, the column "COMPUTE Δ_{jk}" includes logical values "yes" and "no". The contents of this column are decided based on the base station identifier code BSIC. If BSIC is identical for any two cells, the COMPUTE Δ_{jk} is set to a true value. In the opposite case it has a false value.

Observed Time Difference OTD_i for an i:th entry is defined as follows:

$$OTD_i = TOA_i - TOA_1,$$

for all $1 < i < n+1$; where TOA_i is the measured time of arrival i.e. the beginning of the synchronization frame for the i:th entry, and the serving cell is the first entry.

The contents of one of the preferred mapping rules included the condition "a cell is selected when its measured time difference deviates from measured time differences for other cells sharing the same base station identity code more than a predefined threshhold". In Figure 5 terms this can be put into the following context:

$$\begin{aligned}\Delta_{jk} &= \| OTD_j - OTD_k \| \\ &= \| TOA_j - TOA_k \|;\end{aligned}$$

for all $j \ddagger k$; and $1 < j,i < n+1$.

So now the $\Delta_{23} = \Delta_{32} = \| T_{C1} - T_{C2} \|$. If this is below a predefined threshhold, say ε, where ε / T_{C1} can be any relatively small value, say 2,5% - 25%, it can relatively

certainly be deduced that sectors C1 and C2 belong to the same cell and then only one of them is to be selected.

As a consequence, only one of the sectors C1, C2 is selected to the second set in step L23 and the measurement of the sector not selected can be avoided. The selection rule "the cell having the largest signal strength among all cells sharing the same base station identity code and having a measured time difference deviating less than or equal to the predefined threshhold" means that the received signal strength RXLEV in the mobile terminal can be used to select the stronger cell or sector.

One of the main reasons behind this solution is that now the consecutive measurements of sectorized Base Stations 104 can be avoided. The comparison of the time differences is included in some embodiments of the invention, because some operators are using base station identifiers repetitively. Then it would endanger the success of the locationing if the observed time difference OTD for such a cell would not be measured.

Using a 10 second measurement interval, the standby time of a test mobile phone was reduced from 270 hours to roughly 90 hours. It is clear that the 180 hour reduction in the standby time is very significant for the user. If an operator chooses to repeatedly use sectorized cells, the savings obtained by performing step L23 and repeating steps L25 and L27 instead of steps L19 and L21 saved already in our example 25% of OTD measurements. Then, depending on the cellular network 100 structure, it is possible to obtain very significant improvement in the standby time because of smaller energy consumption in the mobile terminal 101.

Although the invention was described above with reference to the examples shown in the appended drawings, it is obvious that the invention is not limited to these but may be modified by those skilled in the art without difference from the scope and the spirit of the invention. For example, any cellular network having similar neighbour list and base station identifier structure as described can be used. Such networks especially include most GSM, GPRS and UMTS/WCDMA networks.

Claims

1. A method for forming a set of cells for time difference measurements for a mobile terminal (101) camped on a first cell (103a) of a cellular network (100) and being in idle mode comprises the steps of:
   - receiving (L13) a first set of cell identifiers of neighbour cells for said first cell (103a); each of said neighbour cells sending a radio signal; and
   - measuring (L15) received signal strength for cells the identifiers of which are included in the first set; a number N of cells having a signal strength exceeding a predefined thresshold constituting (L17) a set of available cells;

   wherein the improvement **comprises** the steps of:
   - reading (L19) a synchronization channel for the set of available cells, thereby measuring (L21) time differences for said set of available cells; and
   - selecting (L23) a second set from the set of available cells using a predefined selection rule, the second set including M < N cells, thus forming a set of cells for time difference measurements.

2. A method for measuring time differences for a mobile terminal (101) camped on a cell (103a) of a cellular network (100) and being in idle mode, wherein the improvement of the method **comprises**: measuring (L27) time differences only for cells in the second set of neighbour cells as defined in claim 1.

3. A method according to claim 1 or 2, **wherein**: time differences are measured (L27) for cells in the second set

of neighbour cells only while an exit condition (L29) is not fulfilled.

4. A method according to claim 3, **wherein:** said exit condition (L29) includes a counter exceeding a predefined limit value.

5. A method according to claim 3 or 4, **wherein:** said exit condition (L29) includes a timer exceeding a predefined time limit.

6. A method according to claim 3, **wherein:** said exit condition (L29) includes the mobile terminal changing from idle to dedicated mode.

7. A method according to any one of claims 1 to 6, **wherein:** said predefined selecting rule at least partially reads: a cell is mapped to the second set whenever:
   - i) a base station identity code of the cell is not equal to a base station identity code of any other cell available;
   - ii) if a base station identity code of the cell is equal to a base station identity code of any other cell available, and:
     - 1) its measured time difference deviates from measured time differences for other cells sharing the same base station identity code more than a predefined threshhold; or
     - 2) it has the largest signal strength among all cells sharing the same base station identity code and having a measured time difference deviating less than or equal to the predefined threshhold.

8. A method for locating a user of a mobile terminal, **characterized in that:** the location of the user is obtained using time differences obtained in accordance with any one of the claims 1 to 7.

9. A method according to claim 8, **wherein:** the locationing is performed on the network side in response to transferring the time differences obtained.

10. A method according to claim 9, **wherein:** said transferring is performed in response to a call originated by or terminated to the user.

11. A method according to claim 10, **wherein:** said call is a E911 service call.

12. A mobile terminal **comprising:** means adapted to carry out the method according to any one of the preceding claims 1 to 10.

13. A mobile terminal according to claim 12, **wherein:** said mobile terminal is a GSM terminal.

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Abstract

A device and method for forming a set of cells for time difference measurements, measuring time differences and locating a user of a mobile terminal

A method for forming a set of cells for time difference measurements for a mobile terminal (101) camped on a first cell (103a) of a cellular network (100) and being in idle mode comprises the steps of:

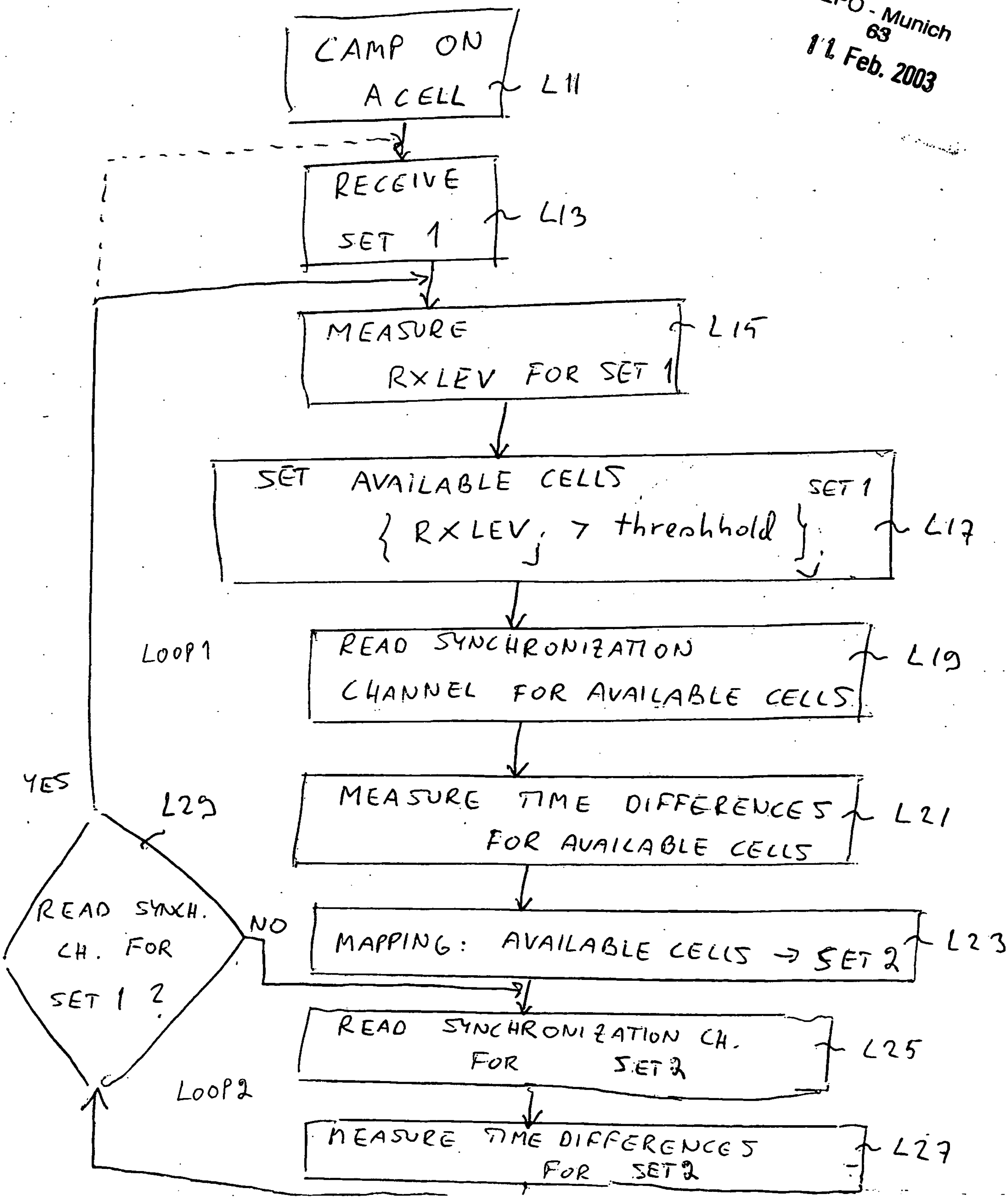
- receiving (L13) a first set of cell identifiers of neighbour cells for said first cell (103a); each of said neighbour cells sending radio signal on synchronization channels; and
- measuring (L15) received signal strength for cells the identifiers of which are included in the first set; a number N of cells having a signal strength exceeding a predefined thresshold constituting (L17) a set of available cells;

wherein the improvement **comprises** the steps of:

- reading (L19) the synchronization channels for the set of available cells, thereby measuring (L21) time differences for said set of available cells; and
- selecting (L23) a second set from the set of available cells using a predefined selection rule, the second set including M < N cells, thus forming a set of cells for time difference measurements.

Figure 4

FIG 4


CAMP ON A CELL
L11
RECEIVE SET 1
L13
MEASURE RXLEV FOR SET 1
L15
SET AVAILABLE CELLS
SET 1
{ RXLEV$_j$ > threshhold }$_j$
L17
LOOP 1
READ SYNCHRONIZATION CHANNEL FOR AVAILABLE CELLS
L19
YES
L29
MEASURE TIME DIFFERENCES FOR AVAILABLE CELLS
L21
READ SYNCH. CH. FOR SET 1 ?
NO
MAPPING: AVAILABLE CELLS → SET 2
L23
READ SYNCHRONIZATION CH. FOR SET 2
L25
LOOP 2
MEASURE TIME DIFFERENCES FOR SET 2
L27

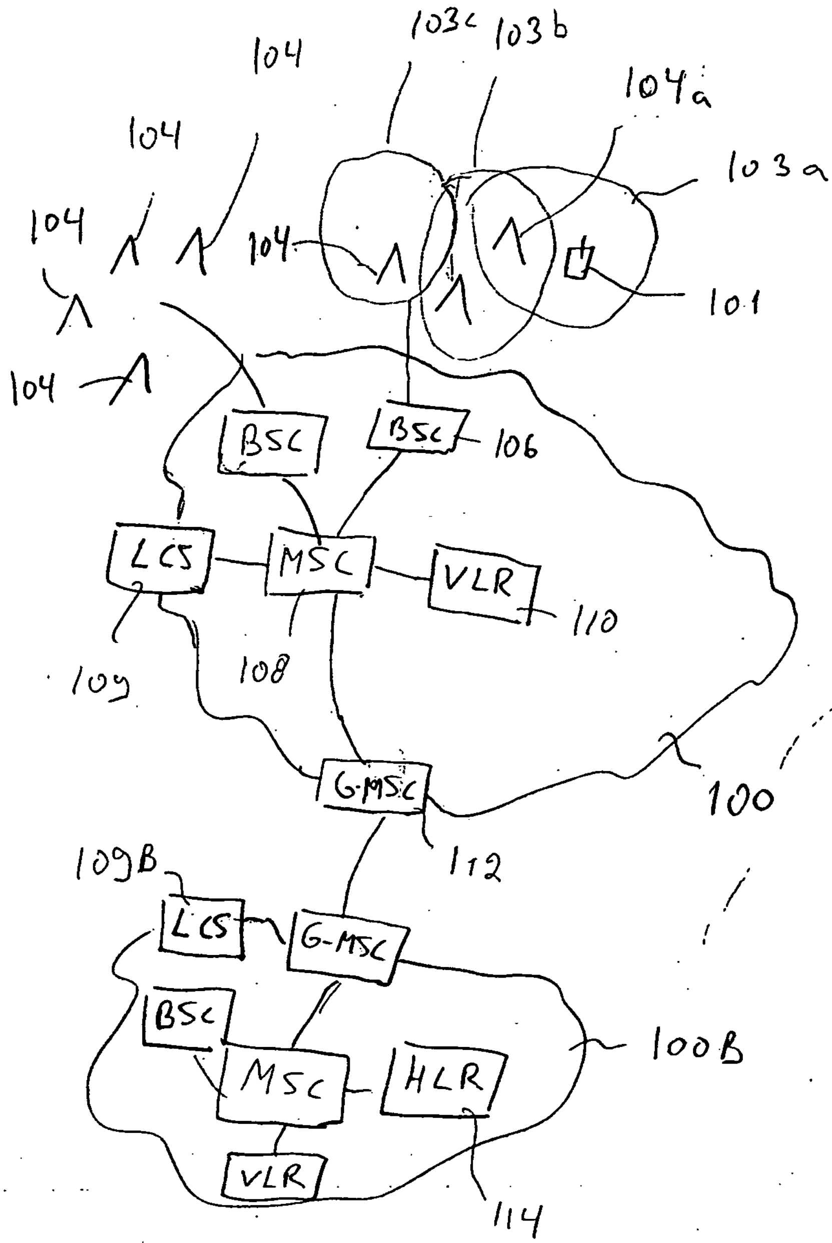

103c
103b
104
104
104a
103a
104
104
101
104
BSC
BSC
106
LCS
MSC
VLR
110
109
108
G-MSC
100
112
109B
LCS
G-MSC
BSC
100B
MSC
HLR
VLR
114

FIG 1

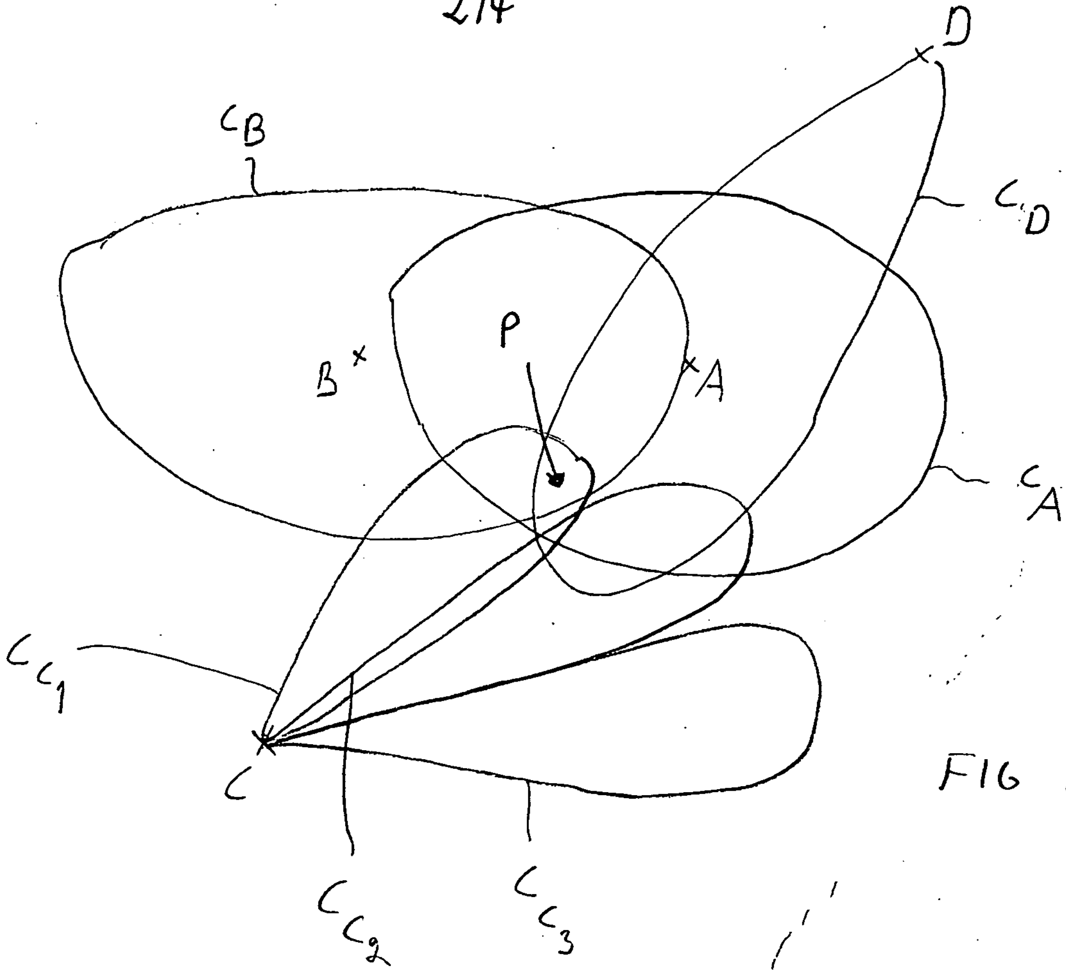
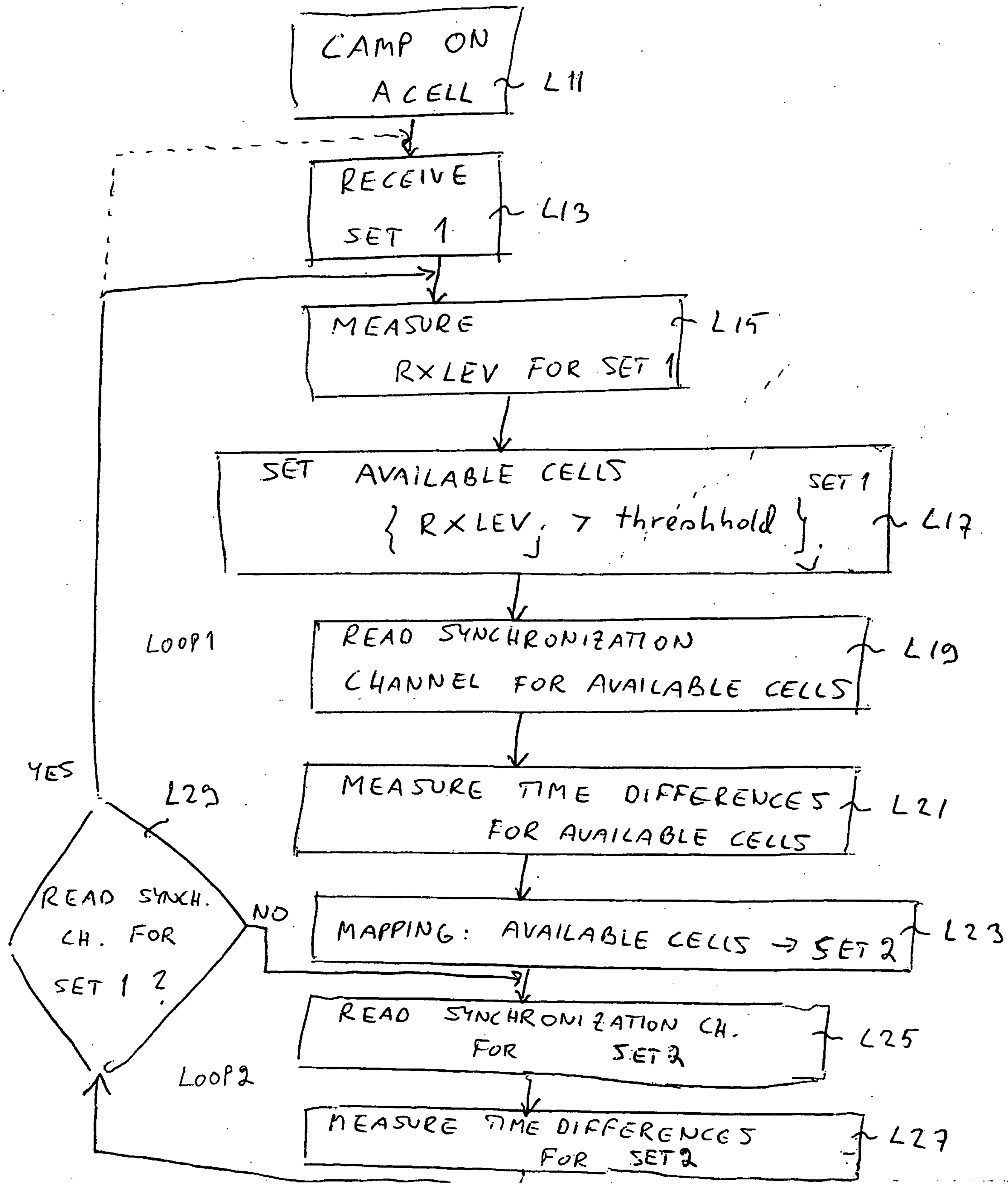


FIG 2

BSIC	BCCH	TOA	OTD
A	a	T_a	–
B	b	T_b	$T_b - T_a$
C	c_1	T_{c_1}	$T_{c_1} - T_a$
C	c_2	T_{c_2}	$T_{c_2} - T_a$
D	d	T_d	$T_d - T_a$

FIG 3

FIG 4


CAMP ON A CELL
L11
RECEIVE SET 1
L13
MEASURE RXLEV FOR SET 1
L15
SET AVAILABLE CELLS
{ RXLEV$_j$ > threshhold }$_j$ SET 1
L17
LOOP1
READ SYNCHRONIZATION CHANNEL FOR AVAILABLE CELLS
L19
MEASURE TIME DIFFERENCES FOR AVAILABLE CELLS
L21
YES
L29
READ SYNCH. CH. FOR SET 1 ?
NO
MAPPING: AVAILABLE CELLS → SET 2
L23
READ SYNCHRONIZATION CH. FOR SET 2
L25
LOOP2
MEASURE TIME DIFFERENCES FOR SET 2
L27

i	$BSIC_i$	$BCCH_i$	TOA_i	OTD_i	COMPUTE Δ_{jk}	Δ_{jk}
1	A	a	T_a	–		
2	B	b	T_b	$T_b - T_a$	NO	
3	C	c_1	T_{c_1}	$T_{c_1} - T_a$	YES	$\lVert T_{c_1} - T_{c_2} \rVert$
4	C	c_2	T_{c_2}	$T_{c_2} - T_a$	YES	$\lVert T_{c_1} - T_{c_2} \rVert$
5	D	d	T_d	$T_d - T_a$	NO	
⋮						
n						

$$OTD_i \equiv TOA_i - TOA_1 \quad ; \quad i = 2 \ldots n$$

Note: $$\Delta_{jk} \equiv \lVert OTD_j - OTD_k \rVert \qquad j \neq k, \quad 2 \leq j, i \leq n$$

$$= \lVert TOA_j - TOA_k \rVert$$

FIG 5